The Terminator HLG

[Courtesy of Bill Grenoble, Denny Maize and Joel Foner]
Last updated on 06/30/00

One day, we had an idea... What if we could design a pretty high performance HLG that 'non-experts' could build and fly successfully, and could be built for about $20-30 of materials? Many tries later, here it is! The Terminator performs almost as well as some of the expensive "super HLG's" yet costs only a tenth as much to build.

We've introduced dozens of new flyers to HLG with this ship, and can attest that it flies well, people love to fly it, and it has drawn many new people to the sport of radio control soaring. Take a look at the construction notes - you'll be amazed how easy it is to build your own Terminator!

Here are a couple more pictures (these are thumbnails - click on each thumbnail to view the full-size image).


Some neat color schemes


A "Terminator Gang" that showed up at a recent contest - and did pretty well!

Is the Terminator right for me?

We assume a couple of things about your experience and skill level in these instructions. The completed Terminator is docile, and you don't need to be an expert to keep it in the air, by any means. Terminator fuselages are strong enough to withstand a large number of "surprising" landings without coming apart, and just about the only thing that can outlast it in a true beginner flyer's hands is an EPP trainer like the MAD Highlander EPP sailplane trainer. We do assume that you have built some sort of RC aircraft kit(s) before, and hopefully have some experience building something from balsa built-up style kits, as opposed to EPP "foamie" slope soarers or ARF-style planes.

The Terminator is very easy to build if you have some previous building experience. Having a local experienced builder to ask questions of will go a long way to getting you in the air with a minimum of 'fuss and bother'.

If you're an experienced builder, but haven't tried HLG before, or have been looking for a straightforward project to jump-start you into building composite-winged ships, or are curious about HLG's but haven't wanted to spend 'big bucks' to try one, then the Terminator is probably for you!

If you don't have much experience building, and you have or can find an experienced builder to help you, don't worry - you'll do fine!

If you don't have much experience building from built-up kits, and can't find anyone local to help, you might find the Terminator a bit challenging. By all means - give it a try. If you are looking for a challenge, and are willing to experiment and try things until you figure out how to work the details, then go for it - you'll have a blast! One thing to note, in terms of expectations - on the Getting Started page we mention that Terminators can be built in two or three evenings. If you're starting from scratch, without building experience, and maybe without basic tools, you should expect it will take longer. How much - well, that depends, but once you've built a few you'll be able to crank them out quickly too. In addition, if you are starting from scratch, you'll find that buying the parts will cost more than the $20-30 that we note - this

assumes that you are pulling from your workshop for some of the pieces. (For instance you have bits of plywood floating around that you can cut up, instead of having to buy a whole new sheet just to use a small part of it, and other such things.)

Want to build a Terminator? Click here for building notes and plans!

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Getting Started

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[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on July 18, 2000]

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You will need the Adobe Acrobat Reader v3 or higher to view or print some of the design items on this page. If you need a copy of the Adobe Acrobat Reader, you can download it free from http://www.adobe.com/products/acrobat/readstep.html.

NOTE: If only part of a page prints when printing the enclosed PDF files, please download and install the latest Acrobat Reader (v3.02 or later) - apparently earlier versions had a problem with large graphics on some printers.

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Please feel free to write us with questions, ideas or flight reports of your experiences with the Terminator.

Introduction

The Terminator concept came from a simple realization: There is a need for a club HLG that is easy for a beginner to build and fly, yet provides "real" performance - at a price that "the rest of us" can afford. Lots of experiments later, the design presented below became real. Dozens and dozens of Terminators have been built, with some interesting design variations.

The design presented here is a good starting point, and has proven to be reasonably competitive - but please treat this as a starting point. Play with it! At about $30 for a completed ship, have some fun! Once you've built a "stock" one, try new wing layouts, airfoils fuselage designs, or just build a hangar of spare parts for less than the cost of one "super" HLG.

It's amazing what you are willing to try and what you will learn when each landing is not a $200 calculated bet!

How does the Terminator perform? Everyone who has flown one raves about it's handling and ability to take advantage of lift. Is it "better" than one of the "super HLG's"? No. Will it outperform one of the well-known "monster HLG's" designed by the masters? No. It wasn't intended to be one of those - it was intended to be a great everyday ship with nice handling and good thermalling capabilities. At the same time, it's done pretty well in contest settings, so don't write it off as a beginner's ship only - your next competitor may be a Terminator!

EVERYONE asks us "do you make a kit"? We don't make a kit - on purpose! We believe that once you learn to build a Terminator yourself, you will feel much more comfortable playing around with it and coming up with your own ideas to advance the art. Part of the Terminator project concept is the idea that keeping the hobby fresh depends on people doing actual building, not just buying expensive pre-built ships, and we're trying to keep the building part of the hobby alive and vital.

What Does It Take To Build A Terminator?

Building a Terminator is actually a really simple project. How do you build a Terminator?

1. Buy $20-30 of materials
2. Build the fuselage (a handful of easy to cut out parts and a carbon fiber arrowshaft)
3. Create a set of foam wing cores (one of your club buddies will jump to help with this!)
4. Sheet the cores with balsa, or if you want to get fancy find someone who can help you vacuum bag them
5. Cut out the v-tail, cover it and glue it on
6. Install your radio and go fly!

****** Before you say "oh, but I don't know how to do foam cores and sheeting or vacuum bagging" - think about this:*** The Terminator was conceived as a club ship - ask around and you will almost certainly find a member of your local club who would be more than willing to cut some Terminator cores for you. Probably as part of the deal you'll even learn how to do it yourself! Who knows, maybe this would make a great club project? How about getting together and building a set of 5, 10 even 20 of them for anyone who wants to help. That's how we got going, and now they're getting hard to count! Ask your club buddies who's got a foam cutter - once they see the design they'll be dragging you into the workshop to core a handful of wings.

Once you learn how to cut your own cores you'll wonder why you were ever scared of it - it's easier and faster than built-up wings, and at a few bucks a shot you can afford to blow up a wing every weekend (or try a new wing design idea each weekend) without even thinking about it (this is not to say that learning to fly better isn't a worthwhile goal - just that knowing that you can build a replacement for less than a dinner lowers the stress level of flying a whole bunch).

If you'd like to build your own foam cutter, click here for Del Brengman's foam cutter plans. Check out the plans and see what you think. If you don't want to get into building your own foam cutter there are several good commercial units - ask your local club members what they recommend.

****** But I'm still unsure of how this foam cutter thing works!***

Del Brengman has a two hour video that walks through the entire process of cutting sailplane wing cores with the foam cutter shown in his plans, and then the vacuum bagging of that same wing all the way to 'the end'. It's definitely not Hollywood for production style, but the information is there, and you get to see the whole process from start to finish without any marketing spin - other than the pitch that you ***can*** do this! To order a copy, send $25 + $2 shipping to *Delmar Brengman, 6054 Emlyn Ct., San Jose, CA 95123*. (this info is also on the bottom of page two of the foam cutter plans)

Aerospace Composite Products also has a video on vacuum bagging that sells for about $20 (see their link in our Companies page).

Terminator Specifications

Wing Span	59"
Wing Area	387 sq in
Airfoil	modified S4083
Wing Plan	Flat 7" chord center section (21" wide), 20" outboard panels tapered from 7" to 5" chord, 1% washout in tip section only, straight trailing edge and swept tip leading edge
Dihedral	Flat center section, with 4" of dihedral at each tip
Weight of balsa pod and carbon boom	~1.2 oz
Weight of balsa v-tail, covered	~0.5 oz
Weight of vacuum bagged fiberglass wing	~4.1 oz

Weight of 1/32" balsa sheeted wing	~4.5 oz (you don't have to do vacuum bagging to make high performance Terminator - balsa sheeted is durable, easy to build and light too!)
Flying weight	Typically 9.5 - 10.5 oz.
Building time	two to three evenings (we now can build seven in a night!)

Typical Terminators come out between 9.5 and 10.5 ounces, which yields a ship that is very, very responsive to lift. Getting to this weight does not require outlandish building techniques of fancy equipment. This weight assumes that you will be using a "standard micro" receiver, such as a HiTec 555 or FMA Fortress or Tetra, with micro servos such as the CS-20/21, FMA S80/90's or HiTec HS-50's or HS-80's and a 110-150 mAH flight pack (several folks have used 225 mAH packs, carefully placed for balance point, for extended flight times on the slope)

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Wing

[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on November 08, 1999]

Wing Overview

The standard Terminator wing has a flat center section with polyhedral tips. The Terminator center section is a flat one-piece core, 21" long, with a 7" chord and a standard 8.01% thickness S4083 airfoil. The Terminator tip section is 20" long, and tapers from a 7" chord to a 5" chord. The S4083 airfoil is transitioned from 8.01% thickness to 5% thickness from the tip section joint to the wingtip, and there is 1% of washout at the tip.

The polyhedral tips are attached with 4" of dihedral under each wingtip.

For those who have not done composite wings before, the general construction sequence is:

1. Cut foam wing cores
2. Cover with balsa sheeting or fiberglass (still in separate panels)
3. Join the panels at the indicated dihedral angles
4. If balsa sheeted, finish the wing to prevent the wood from picking up moisture

Note: The trailing edge of the Terminator standard wing is straight, across both the center and tip sections - all of the chord taper is done with a leading edge sweep. Please see the pictures on the intro page for pictures of the wing layout.

What Kind of Foam Should I Use?

This is one of the most common questions we have been asked. We have had good luck with the pink foam sold in sheet form at Home Depot. It seems to be much stronger than white foam, at a very slight weight penalty. For us, the strength advantage is worth the tradeoff, since it is harder to fold the completed wing.

For a stronger wing, use pink foam for both the inner and outer panels.

For a lighter wing, but not as strong, use Home Depot pink foam for the inner panels and 1 lb virgin white foam for the outer (tip) panels.

Wing Core Templates

Below are templates in two formats for both fiberglass bagged and balsa sheeting wing designs. Templates are provided in Acrobat PDF and CompuFoil 98 LFT format (these templates use an airfoil included in the CompuFoil Airfoil Library - without the library they will not load). CompuFoil 98 will give you the most control over template creation, and allow customization easily. On the other hand, creating templates from a PDF file does not require you to purchase software (but you must check the template printouts as noted below to be sure they're sized correctly!).

ADOBE ACROBAT FORMAT TEMPLATES (.PDF)

Section	Fiberglass Bagged	1/32" Balsa Sheeted
Middle panel and innermost template of tip section (the one that connects to the center panel)	termctrg.pdf	termctrb.pdf
Wing tip template (with 1% washout)	termtipg.pdf	termtipb.pdf

NOTE: ***Be sure to check the dimensions of your template printouts*** *if you are printing them using the Adobe Acrobat PDF files! On most printers they will be full size, but on some printers the size may not be correct! The chord of termctrg.pdf and termctrb.pdf should be a full 7", while the chord of termtipg.pdf and termtipb.pdf should be a full 5".*

If your printer does not render these at full size you have two options. You can either take the printouts to a copy shop and fiddle with the enlarge/reduce function of their copier until they come out the right size, or purchase a copy of CompuFoil, and use the CompuFoil LFT templates below instead. (The CompuFoil web site is at http://ourworld.compuserve.com/homepages/compufoil/).

LEADING EDGE TEMPLATES

Here are leading edge templates, to help shape the leading edge correctly. Each template has two airfoil curves; the inside curve is for the foam on a sheeted wing, the outside curve is for the foam on a bagged wing (or either completed wing).

Section	Template
Middle panel and innermost template of tip section (the one that connects to the center panel)	trmctrle.pdf
Wing tip template	trmtiple.pdf

COMPUFOIL 98 LOFT FORMAT TEMPLATES (.LFT)

NOTE: These templates use an airfoil that is included with the CompuFoil Airfoil Template library option, but is not included in the "base" CompuFoil 98 product. Without the Airfoil Library option, CompuFoil will likely not be able to load these templates.

Section	Fiberglass Bagged	1/32" Balsa Sheeted
Middle panel and innermost template of tip section (the one that connects to the center panel)	termctrg.lft	termctrb.lft
Wing tip template *Note: Make **sure** to add 1% washout to this template in CompuFoil **before creating your templates**. (The LFT file format does **not** preserve the washout settings. To set the washout angle in CompuFoil 98, select the airfoil menu and then click on the washout angle menu item.)*	termtipg.lft	termtipb.lft

*NOTE: **Be sure to check your CompuFoil printouts for accuracy.** Not all printers are accurate at the level needed to create clean airfoils - don't assume that yours is without checking it. To check your printer calibration with CompuFoil 98, use the Adjust Printer Aspect Ratio item on the Defaults menu. (Make sure to write down the original settings before tinkering, just in case!)*

Click here to download a PKZip archive containing all four CompuFoil LFT files (this is helpful if for some reason CompuFoil will not open the airfoils correctly when you click the links above.

Finishing the Wing

The Terminator wing can be finished either with balsa sheeting or glass bagging techniques.

BALSA SHEETED OPTION (balsa sheeting step-by-step created by Dan Griscom - thanks!)

If you are going to balsa sheet the wing, find enough sheets of 30" x 4" x 1/32" balsa to cover the surface. (If you will be building a bunch of Terminators in a club-style project, you should consider buying a 100 sheet lot of balsa so that you can pick the weights that you want and end up with matched panels.)

The balsa sheeting can either be attached with 3M77 spray adhesive, or if you (or a club buddy) has vacuum bagging facilities you could bag the balsa on with epoxy. *NOTE: 3M77 is a contact cement - you get one try to get the sheeting aligned - be careful to get things lined up before you let the sheeting touch the core!*

1. Tape a pair of 1/32" x 4" sheets together with Scotch tape. Bend the joint open, apply some Elmer's or carpenter's glue to the edge joint, open the sheets up flat, and wipe excess glue off of joint with a damp paper towel. Glue six pairs of sheets this way and let them dry overnight.
2. Put the bottom core blank on a flat surface, cover with wax paper, and place a wing core on top.

3. Cut the 8" balsa sheet to fit the core, leaving extra on all edges.
4. Spray the balsa sheet and the core with 3M77, and let dry until tacky.
5. Starting at the trailing edge, touch the balsa to the core and smooth the balsa onto the core until you reach the leading edge.
6. Trim the balsa flush to the core, except for the trailing edge. Since the foam core doesn't reach all the way to the trailing edge of the airfoil, the balsa should overhang 1/3" past the trailing edge on the center section and at the inner ends of the outer sections, and 3/4" past the outer ends of the outer sections.
7. Put the top core blank upside-down on the flat surface, and put the half-covered wing core upside down on top.
8. Spray balsa and core with 3M77, let dry until tacky, apply balsa, trim to core (again, except for the trailing edge).
9. Stack bottom core blank, wing, and top core blank, weight down until flat, and let dry for 24 hours.
10. Sand the leading and trailing edges to shape, and run a length of 3/4" tape along the leading edge to cover any leftover gap.

Finishing the sheeting is easy. Just sand with 320 (lightly - don't go through it!), and then finish it with either water-based polyurethane or an alcohol-based shellac (make sure you get the kind with built-in sealer) like Bullseye. Applying either one with a 2" brush is quick and creates a nice finish. Finish sand and you're done with the wing. Option: Tinting Polyurethane for a colored finish

VACUUM BAGGED FIBERGLASS OPTION

For general hard use, bag the center and tips with 1.5 oz cloth. The steps below should yield a 4.5 ounce wing:

- Add a top center doubler of 1.5 oz cloth (5" by full span)
- Add a bottom center doubler of 1.5 oz cloth (3" by full span)
- Add two pieces chordwise in the center (measured) of 1.5 oz cloth - one 2" wide and the other 3" wide. These reinforce the center of the wing where the wing bolts will go through.
- Add a doubler of 1.5 oz cloth to the top only of each tip panel, 3" wide by the full span including the tip.

That's it! Try to bag with two ounces or less of resin for the whole wing. If you use a 4" roller it will help you to be light on the application. For a 4.1 ounce light wing, change the tip cloth and doublers to .75 ounce cloth and reduce the amount of resin on them. (Note that if you do "gorilla launches" this lighter wing will fold more easily...). Click here if you want to check out the "How to Bag a 4 Ounce Wing" option page.

Now this option is really not for first-time "baggers", but for those of you who want to try something more adventurous, take a look at Bill's Terminator Bagged Tips. This page describes some special work that Bill likes to do on the tips - seems to get a bit more launch

height and more tip stall resistance.

Assembling the Wing

Once you cut the cores for each wing section, they can be attached with a layer of 5 minute epoxy. The center section should be set flat on your work surface, and the tip joint carefully sanded until it is a flush fit with the underside of each tip 4" above the work surface.

Once you have sanded the correct angle into the tips, here is a quick and easy way to join them.

1. Find (or cut) something in your shop that is 4" high to use as a tip dihedral brace
2. Using a #11 blade (X-Acto type works well), tap randomly on each mating surface where the panels will be joined. This will make some tiny "woodpecker" holes in the foam surfaces that will be joined, and ensures that the epoxy can flow into the foam and not just form a surface bond.
3. Take some tape (Scotch tape or packing tape works fine) and hinge the tip section onto the center section on the bottom surface, so that when you flex the tip up to the 4" set point the foam is tightly mated.
4. Unfold the tip, leaving the tape in place, mix up some 5 minute epoxy, and brush onto the foam, making sure that the epoxy flows into any foam crevices and the perforations made in step 2.
5. Gently fold up the tip and rest it on the dihedral brace.
6. Excess epoxy will flow out of the top of the dihedral joint - I use craft sticks to "scoop up" the extra epoxy right away - and if you work reasonably quickly you can then wipe off any remaining layer of epoxy with paper towels.
7. When the epoxy is cured, peel off the tape on the underside of the joint, and voila - you're done!

If you want to cover up the joint, almost anything will do - electrical tape, covering material, trim sheets, whatever. The wing will not need any extra strength in this joint after the epoxy, so resist the urge to glass over the joint - it's wasted weight!

Installing the Wing Hold-Downs

We use two aluminum 6x32 bolts (front and rear - about 5" apart) to hold the wing on. The exact location isn't too critical, but on many wings we set up the front bolt 3/4" from the leading edge, and the rear bolt about 5" behind. To keep the wing from being crushed at the bolt locations, make up a couple of "washers" out of 1/16" plywood, about 1/2" in diameter, and glue them to the upper wing surface with thick CA. (These don't need to be round - we cut them 1/2" square and just sand or cut them to be "roughly round").

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Fuselage / Tail

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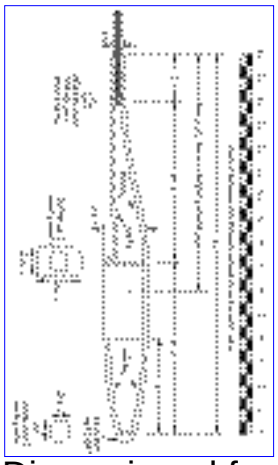
[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on November 08, 1999]

Fuselage Overview

The Terminator uses a simple pod and boom design. The fuselage uses a minimum of parts, yet is quite strong.



Dimensioned fuselage plan - click the small thumbnail image above for a large image.

*** Don't sweat the specific shape of the fuselage pod, as long as the basic dimensions in the drawings are adhered to. Here's a picture with some experimental fuse pods we've built. Just make sure that the length from the wing to the tail stays the same, the angle of the wing to the tailboom stays the same and there's enough space for your gear and it'll fly fine!

But where do I get the arrowshaft for the tailboom? There are archery shops in most cities, and these shops carry a variety of arrowshafts. Several types can be used for the Terminator. We have used arrowshafts from two major vendors, Beman and Easton. We use the Beman ICS 500 whenever we can find them - they are lighter and slightly larger in diameter than the Easton arrowshafts (less flex and lower weight).

Note: The standard Terminator tail boom, from the front of the wing saddle to the rear tip of the tailboom, is 26.5"-27". (This is written up this way so that if you choose a different fuselage shape or design it is easy to get the overall tail length correct.)

If you cannot get the Beman, then the Easton ACC 328 or 339 will work (in order of size and weight - the 339 is the heaviest - anything lighter than the 328 is likely way to flexible). Almost any carbon arrowshaft will do, although the smaller diameter shafts may take some extra work, and may have too much launch flex. Some are very small diameter - these can be used, but the control wires may need to be run down the outside (CA the sheath in place every couple inches if you opt for this approach).

Create the Fuselage Sides


Fuselage sides with doublers (click for full-size image)

1. Cut two fuselage sides from soft 3/32 balsa. Hold the two together and sand so they are exactly the same.
2. Using the fuselage sides as a pattern, cut out two 1/64 plywood doublers. (these are best cut with household scissors)
3. Making sure to make a right and left side attach the doublers to the fuselage sides with thick CA.
4. Attach 3/16 or ¼ triangle stock flush with the bottom of both fuselage sides along the full length of the bottom using thin CA
5. Attach 3/16 or 1/4 triangle stock flush with the top of the front 4" of both fuselage sides, using thin CA.
6. Attach 1/8" square balsa along edge of wing saddle, using thin CA, stopping where the boom former will be installed.

Assemble Fuselage


Fuselage in alignment jig (click for full-size image)

1. Cut the center former from 1/8 light ply.
2. Click here to download an Adobe PDF file showing how to make a very simple jig for aligning the fuselage (5 kB PDF). The braces for the nose former should be 7/8" apart; the braces for the center former should be 1 7/16" apart, and the holder for the rear of the fuselage should be 5/8" wide.
3. Place the sides in the jig upside down and slide the center former into place making sure it is aligned properly with the end of the plywood doublers. Make sure that everything is pushed down squarely on the jig surface and zap the center former with thin CA to hold things in place.
4. Make the nose former from 3/32 balsa and thin CA it in place

Add Fuselage Sheeting



Adding top and bottom sheeting (click for full-size images)

1. Now you can start sheeting from back to front on the bottom of the fuselage using light 3/32 sheeting cross grained I use thick CA for this and make sure to glue full width on the triangle stock also as you will sand much of the corner away when you finish the fuselage.
2. When the bottom is sheeted the fuselage may be removed from the jig and triangle stock fitted to the top from the center former to the nose former with thin CA.
3. The first 4 inches of the top is then sheeted with 3/32.

Mount the Tail Boom


Fuselage ready for tail boom attachment (click for full-size image)

1. At this time you must cut the boom former from 1/8 light ply and glue it into position. Make sure to make the hole for the boom slightly oversize so that you have room to align the boom. ***MAKE SURE THAT THE HOLE FOR THE BOOM IS BELOW THE LEVEL OF THE FUSELAGE SIDE TOPS!***

 Tailboom in fuselage pod, ready for glue (click for full-size image)

2. Slide the tail boom into the former from the rear about 3/16 past the former. Holding the fuselage upright the tail boom will pretty much self center in the triangle stock. Sight from front to back to check alignment. The boom may be adjusted slightly if necessary since we made the hole slightly oversize. When you are satisfied with right to left alignment put a drop of thick CA on top of the boom at the former.

3. Now fill the space between the sides and the tail boom at the extreme rear of the fuselage with tiny pieces of scrap balsa so that it remains aligned right to left but can still move up and down.

 Final fuselage pod and boom alignment (click for full-size image)

4. Turn the fuselage over and block the rear up so that the wing incidence angle is level with the workbench top. Now block the tail boom so that the top side (now the bottom side since we are upside down) is also level with the workbench top. When you are satisfied that both the wing incidence and the boom are level with the workbench top put a drop of thick CA on the boom at the rear of the fuselage to hold it.

> Here's an alternate boom alignment method from Dan Griscom. Lay your fuselage side on poster board and draw just the top section containing the wing saddle and rear top of the fuselage to the end. Then, trace the center wing panel airfoil onto the wing saddle, just as the wing will be placed when the Terminator is assembled. Draw a straight line through the chord line of the airfoil (through the center of the leading edge and the center of the trailing edge), extending it about 12" beyond the trailing edge.
>
> Tack the front of the boom to the boom former with a bit of CA, leaving some space for it to move around. Hold the fuselage and

boom against your template, moving the boom up and down until it is parallel to the extended chord line. Tack the rear in place, pick up the fuselage, sight the boom straight, and finish glue.


Final boom lock-down with epoxy (click for full-size image)

5. Turn the fuselage right side up and re-check your right to left alignment. When satisfied that alignment is correct fill in the back of the fuselage around the boom with scrap balsa to form a dam. You now have a space between the boom former and the rear of the fuselage which gets filled with 5 minute epoxy mixed with lots of micro balloons (to keep it light) - this secures the boom to the fuselage. ***NOTE: Make sure to push this mixture down around the sides of the boom, etc. to get a good bond on the boom.***

6. Cut the boom off at 26 ½ - 27 inches from the center former.

Add the Wing Saddle and Wing Hold-Down Blocks


Adding wing saddle and hatch support (click for full-size image)

1. The wing saddle from the boom former to the center former is doubled on the inside with 1/8 square balsa and thin CA.
2. At this point the wing hold down blocks can be installed. The lower portion of the front hold down is 1/8 light ply and slides up against the bottom of the 1/8 square doublers and against the center former. The upper portion fits between the doublers and is located so the front wing bolt is about ½ inch back from the leading edge.
3. The rear hold down is constructed the same way and is located so the rear wing bolt is located 5 inches from the front one.
4. The upper hatch is made from light 3/32 balsa. A small scrap of balsa may be used to make a locator block for the front of the hatch. For the time being the hatch may be held on with a small drop of thick CA to the center former. This will allow you to shape the hatch along with the rest of the fuselage.

Sand and Finish (almost done!)

1. Now it is time to get out the sandpaper and shape to your liking. I like to round the corners pretty hard and make a nice aerodynamic shape.

Carefully cut the top hatch loose and remove.

2. When the fuselage is shaped to your liking, the whole thing is covered with a layer of fiberglass cloth (cloth between 3/4 oz and 1.5 oz works fine - 3/4 oz is strong enough to withstand being "piled in" from fairly high up!). Lay the fiberglass over the fuselage and attach it with water based urethane, which acts as the finish as well. Allow this to dry overnight. ***Don't skip this step - with the layer of fiberglass it is very difficult to damage the fuselage pod, and it doesn't add a significant amount of weight!***

An easy technique for applying fiberglass is given in this CRRC tech note.

Here are alternate instructions for covering the fuselage (from Denny Maize, aka rcsoarnut@aol.com):

> "When covering the fuselages with glass I clamp the fuse horizontally from the tail boom and upside down. I use a single piece of 3/4 oz cloth draped over the fuse. I use a foam brush to apply the urethane starting on the bottom and working down both sides (you will have to reach in with your scissors from the front and make a couple of slits to go around the nose contours). When I get the sides covered I stop and trim the cloth so that it will overlap on top. Rotate the fuse and work first one side then the other till they are overlapped and you have your first coat on.
>
> "I do not make any attempt to blot this first coat, nor do I use spray adhesive as I like to get the saturation and penetration of the wood for strength. On subsequent coats where you are just filling the weave you can blot the excess off. This fuse is so small and light that I feel the good penetration for strength on the first coat is worth a lot more than the millionth of an ounce you might save by skimping here. My fuses weigh from 1 to 1.2 oz with the boom installed so I'm not sure what you would save by skimping. I don't think you will properly wet the cloth and wood with a spray can on the first coat, but, for finish coats it would be fine."

Option: tinting water-based polyurethane

Drill and Tap Wing Holddowns

1. You may now locate the ***exact*** center of the wing center section and place the wing on the fuselage.
2. Drill a 7/64" pilot hole through the front edge of the wing, about 3/4" from the leading edge - also drill through the holddown block and tap the block for 6-32 threads.
3. Open up the hole in the wing to accept a 6-32 screw and install a 6-32 x 1" aluminum or nylon screw.
4. Carefully measure and locate the wing by measuring from tips of

center section to the center of the boom - make SURE that when you drill the rear hole the wing is in good alignment (both tips equal distances from the nose or tail.

5. When properly located, drill rear hole ***exactly*** 5 inches from front bolt and tap rear block.
6. Open rear hole in wing and install 6-32 x 1" aluminum or nylon rear wing hold down bolt.
7. To keep the wing from being crushed at the bolt locations, make up a couple of "washers" out of 1/16" plywood, about 1/2" in diameter, and glue them to the upper wing surface with thick CA. (These don't need to be round - we cut them 1/2" square and just sand or cut them to be "roughly round").
8. If you want to be able to finger-tighten and -loosen the wing bolts, cut two 3/8" long sections of arrow shaft, sand the bolt heads until they friction-fit inside the shaft pieces, and then CA the shaft pieces in place.
9. To make the threaded holes stronger, tap them, drip a bit of thin CA into them, wait a bit, and then tap them again.

When you want your next wing to match, screw a cut-off screw you pointed into the front hole. Push the wing down on it, making sure that it's straight, then remove the wing and drill up through the dimple mark. Move the cut-off screw to the back hole, hold the front of the wing down with a screw through your new hole, align the wing, and push the back of the wing down against the point. Drill up through this second dimple, add plywood washers, and you're done.

Install Throwing Grip(s)

Throwing grips are an almost religious topic in the HLG community. Here are the approaches we've seen used for Terminator throwing grips:

- 320 sandpaper glued to the fuselage sides, and add a brace to keep the fuse from getting crushed and use a "squeeze grip" to throw with *(easy to install and use)*
- Install a 3/16" throwing peg at varying locations from the trailing edge to about 1.25" ahead of the trailing edge *(some feel this gives the highest throwing power and control, but you do have to be very careful not to pull down during launch or you can fold the wings!)*
- Cut a hole in the fuselage bottom for a throwing hole *(a classic approach - requires adding a partial height former for your finger to push against)*

- Reshape the rear of the fuselage so that you end up with a finger-grip using the bottom of the fuselage (with a finger grip area just below the wing trailing edge).
  (inspired by the Orbiter HLG, provides an easy high power grip while avoiding the possibility of folding wings due to a pull-down during launch - but does require playing with the fuse design a bit)

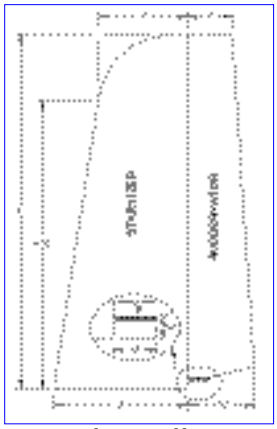
Probably the best thing to do is to talk to your local club members and pick an approach that seems to meet with local approval.

Build and Mount the V-Tail

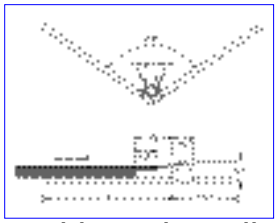
The v-tails are of standard balsa construction. Some folks mount the v-tail to the top of the tailboom. These instructions show mounting it under the tail boom. There are a couple of tradeoff's either way:

On top of tailboom: Less likely to get damaged from landings, since the tailboom protects the bottom of the "v"

Under the tailboom (described here): Allows control horns and linkages to be more streamlined (they don't stick out as much), so the drag profile of the tail is lower. Easier to align. Can be easier to damage, so you might want to put a light coat of glue or light fiberglass along the bottom of the tail "v" joint so that it doesn't get scraped during landings.



Here is a dimensioned diagram of the tail surfaces (click for a large image).



And here is a diagram showing the angle of the tail "v", as well as an illustration of the control horns and linkages (click for a large image).

Here is a picture of what the assembled tail looks like from above (click the thumbnail below for a larger image)

Now for the step-by-step instructions (thanks to Dan again for this step-by-step tail construction guide). (Note: there are a lot of specific dimensions given here. Treat these as loose guidelines, any and all of which may be changed.)

1. Cut the tail parts from 1/8" balsa. Use contest grade balsa (4-6 pounds); if not available, use as light as possible. (You can reduce weight by using 3/32 contest balsa with lightening holes, but the results won't be as strong.)
2. Round the leading edge of each stabilizer and the trailing edge of each ruddervator, and bevel the bottom of the front edge of each ruddervator (see the diagram above if this is confusing).
3. You want to join the roots of the two stabilizers at a 110° angle: with an 8" tail, the tips should be 13" apart. Using a long piece of tape between the tips to set this distance, tack the joint with thin CA, fill the bottom crack up with thick CA, and spray with accelerator.
4. Cover the tail components with film (Ultracote Lite Transparent works well). Make sure to leave 1/2" of space on either side of the top of the joint on the stabilizers, so you can glue down the arrow shaft. Leave the edge of the ruddervators closest to the V-joint bare as well; this is where the control horns are glued. Be careful not to warp the tail when shrinking the film.
5. Hold the stabilizer V against the bottom of the arrow shaft, overlapping the last 2 1/8" of the shaft and leaving 7/8" of the joint uncovered. (You may want to add shims at the front between the shaft and the stabilizers; see note below for details.) Tack in place, fill joint with thick CA, and spray with accelerator.
6. Hold two pieces of 1/32" plywood between your fingers. Use scissors to cut both at the same time to approximately 1/2" high or a little less, and 1/2" wide. Taper one or both sides as you wish, and sand both while still holding them. Then drill a 0.040" hole through both.
7. Temporarily tape each ruddervator to its stabilizer with two small pieces of masking tape, one at either end of the hinge. You should have about 1/4" space from the end of each ruddervator to the V-joint, and each ruddervator should be held at neutral.
8. Hold one of the control horns with a pair of needle nose pliers and apply thick CA to the side you want to attach. Hold it against the inside edge of one of the ruddervators while sighting that you are not over center, and spray lightly with kicker with the other hand. Do the same

for the other side.

9. (In the radio/balance instructions, you'll run the control cables through the shaft and add Z-bends at the end to match the control horns. After bending the Zs, remove the ruddervators, put the Zs through the control horns, and reattach each ruddervator with hinge tape.)

NOTE: We've found that if you add a little negative incidence to the v-tail (rear of the tail a little higher than the front of the v-tail), you'll need less shimming during the tuning phase. In general, we set the rear of the v-tail 1/64-1/32" above the leading edge of the v-tail, although this is really done by eye. "If it looks like it's barely at an angle it's probably about right" (like cooking - sometimes feel counts!). This isn't critical, since you can always add a shim to the LE or TE of the wing as described in the tuning section - and most folks find over time that they like the incidence tuning slightly different anyway. This is another setting that you shouldn't sweat too much - but feel free to put a touch of angle in here if you wish - just make sure to try the shimming experiments discussed in the tuning section regardless of what you do.

And if you really want to build a conventional tail...

Click here to download an Adobe Acrobat diagram of a conventional tail that works well on the Terminator (126 kB).

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Radio / Balance

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[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on November 08, 1999]

Install Radio Gear

There are many workable ways to install radio gear in the Terminator - what follows is one way that we have found to be easy to install, adjust and balance the ship with.

PUSHRODS
Rather than using traditional music wire pushrods, we've had great success using Sullivan #507 cables with the yellow sheaths as pushrod supports (these are the stranded cables, normally used for large ship pull-pull installations). You may be a bit concerned about using cables for pushrods. We were concerned too, but they work very well, they are light and they are easy to work with.

Here's the trick: Make sure that the longest unsupported run of cable is about 1/2" with the servos in their neutral position. This should leave just enough travel to handle full surface deflection, and with only 1/2" or so unsupported, the cables will not flex in compression.

Solder a threaded coupler on the servo end of each cable. The V-Tail end gets a z-bend. Some builders prefer to solder the coupler end first, and then do the z-bend at the tail, while others prefer to do this in the reverse order. Either approach will work fine.

Here is a picture of how the v-tail control horns look once everything has been installed:

 V-Tail control horns with cable linkage (click for full-size image)

SERVO INSTALLATION

The Terminator fuselage is designed a bit larger than the "hotshot" HLG fuselages to make radio installation easier. If you are using Cirrus CS-20's, CS-21's or another servo of similar size, you will be able to mount the servos either stacked parallel to the bulkhead or in a row parallel to the fuselage sides.

Mounting the servos stacked parallel to the bulkhead will allow you more adjustment range of the CG, and will make it easier to reach up front for moving things around, but it's a little trickier to reach in for adjustments. Check the length of your servo arms, and trim the excess arm length so that you attach the pushrods to the hole 9mm from the servo arm pivot point. You will not need more throw, so you can discard any length over this length - it will just make it harder to fit things in if you leave the arms longer!

 One approach to servo positioning (click for full-size image)

V-Tails ***must*** have more down travel than up to work correctly. We've found that with CS-20/21 servos, moving the servo arm one 'click' ahead gives the right throw offset. To do this, center the servos with your radio on, and attach the servo arms so that they are at 90 degrees to the fuselage centerline. Then take each servo arm and re-attach it one "click" ahead - so that the arm is one notch closer to the front of the plane - than the normal 90 degree position.

If you use a servo arm of the length described above and V-Tail control horns of the length shown on the plans, we've found that setting your transmitter throws to around 100% gives a decent control feel.

- Remember that V-Tails need more down than up travel, typically 2:1 for down:up travel. You can obtain this either by setting the travel endpoints in your radio or by setting the arm angles on the servo and ruddervator control arms.

BATTERY PACK

Terminators have flown successfully with either 110 mAH or 150 mAH packs. By moving the pack around, either one can usually result in a

balanced ship without nose or tail weight.

Balancing

The Terminator has a wide balance range. If you are a beginner, try balancing the Terminator about 2.5" - 2.75" from the leading edge of the wing. If you have flown HLG's before, or are used to a more sensitive ship, start with 2.75" - 3" from the leading edge. We use 3" from the leading edge as the "right" balance point for a performance-trimmed ship.

If your Terminator is balanced at 3" from the leading edge, and the nose seems to "ride high", then you may need to reduce the wing incidence (add a 1/16" shim under the rear of the wing trailing edge and try again).

If the Terminator tends to "tuck" on a very hard launch, try adding a small shim under the leading edge of the wing, or reducing the amount of shim under the trailing edge of the wing. Another possible reason for this behavior is a tail boom that is not rigid enough.

Another way to tell if you need to change the incidence is to look at your elevators at the end of a flight. If the neutral position of the tails is slightly down, then you need to shim up the wing trailing edge a bit, and vice-versa if the neutral position is slightly up.

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Flying / Tuning

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[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on November 08, 1999]

Flying Your Terminator

The Terminator is designed to be able to fly faster than the "floater" ships, so you may learn a bit while getting used to it. If you started out with an Olympic, Paragon or similar "floater" ship, here are some thoughts to keep in mind.

"Floater" sailplanes have very narrow speed ranges - typically their fastest workable speed is only slightly above their stall speed, and the optimum thermalling speed is not far from their slowest workable flying speed.

The Terminator has different flying characteristics, and once you learn them, it will reward you with much more flexibility in chasing and hanging onto lift. The Terminator wing has a fairly wide speed range, but unlike the "floaters" a Terminator does best at a speed noticeably higher than its stall speed.

To experiment with this, try a few launches from one end of the field, facing into the wind. For each flight, fly straight out, no turns, until and if you have to turn around at the other end of the field. We're not trying to find lift for a couple flights, just checking out flight behavior at different speeds, so don't worry about where the thermals are for now. For the first few launches, try flying 'slow' - at the speed that feels just above stall.

Then do a few launches with progressively more down trim (add one click down for each throw). Let the Terminator come up to speed and get "on step" - resist the urge to pull up and slow it down right away. You'll find that if you let it hit cruise speed, you'll get noticeably longer flights and longer durations.

(Note that playing with leading edge or trailing edge shims, and moving the center of gravity around, will change the cruise speed and behavior by quite a bit - try some variations and find the one that "flies right" to you.)

Now you have a sense of the "natural" cruise speed for the ship, try to cement this in mind, and fly at this speed while trying for lift. In addition, remember that if you round the top of your throw on the late side, the Terminator will fly at slower speeds, but to get the most out of your throw try to round the top at cruise speed. This way you don't have to give away height just to get the speed up to where it should be. Do not be scared to pull elevator in turns - with enough elevator the Terminator will turn tight at high speeds - do not start off with the assumption that you must slow down to turn tight!

Now try several flights with a second goal in mind (again ignoring thermals - if you can!). For each of these flights, try pulling into a turn just after launch, pulling a tighter turn on each throw. Keep turning until you have to level out to land. Keep trying tighter turns until you hit "the edge" of how tight the ship will turn. Depending on conditions, you may find that you can turn high performance circles of well under 12' in diameter (some people have reported a useful turn diameter of as small as 8'!).

Unlike ships with higher speed airfoils, the Terminator can turn ***very*** tight circles at higher speeds, so it's worthwhile to learn to fly the Terminator faster than your initial reflexes will tell you is 'right'. Flying faster will give you a few quite useful benefits:

- If you don't happen to launch into lift, and you fly at the Terminator's cruise speed (instead of just above stall), you will be able to search around the field much longer than other HLG's to find where the 'real' lift is.
- You will be flying further away from your ship's stall speed, so you will be able to fly on windier days with confidence, since gusts will affect the ship less.
- You will have much better control in thermal turns, since at higher speeds the control surfaces will have plenty of control authority and very little "mush"

Tuning Your Terminator

Here are some things to try while tuning your Terminator:

- Try adding a trailing edge shim, 1/16" at a time. Each shim will speed up the cruise, and often one shim (or so) ends up with the right decalage for this fuselage and tail design. Then try removing the trailing edge shims and add a leading edge shim. Adding LE shims will slow the glide down, but you may find that the Terminator starts to stall too easily, will start to "balloon" too much, or won't penetrate well if you go too far. *If you find that your neutral cruise elevator surface setting is not "dead-level" with the v-tail or elevator you probably need to adjust the wing angle (neutral with elevators "up" slightly - shim the TE, elevators "down" at neutral trim means you should shim the LE).* Small changes in angle may not change the elevator setting much, so feel free to play around even if the elevators trim level at cruise - you may like the results!
- Try playing with the center of gravity. Although the Terminator will fly well through a broad CG range, you may find that somewhere from 2.75" - 3" from the leading edge will give you the best tradeoff between stability and good manners. Although it will fly with a farther rearward CG, some have found that farther rearward balance points may trigger occasional "tucks" under high speed launch conditions (although it does make the plane _very_ sensitive to lift). This will have to be a choice based on your personal preference and flying style.
- If the Terminator seems to balloon a bit when entering a turn, but only while you are holding rudder, then you need more down and less up travel in the ruddervators. If it seems to sink too much in a turn, then you need more up and less down travel. This is pretty personal - some folks like to purposefully "detune" the tails so that turns need very little up until you are fairly well into the turn, while others like to have the response timing feel like a conventional tail ship. Play around until you think it feels natural, and then go fly!

Best of luck - may the lift be with you,

Bill Grenoble, Denny Maize and Joel Foner

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Parts List

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Thanks to Dan Griscom for taking the time to put this list together - finally we have a parts list!

This is an attempt to provide a complete parts list for the Terminator. It assumes a number of things about the plane to be built:

- Default fuselage shape
- Default boom length, tail size
- Balsa sheeted wings, using 3M77 adhesive and no vacuum bagging system
- No extraordinary efforts to reduce weight

Like the rest of these plans, this list is NOT designed to limit your creativity, just to provide a starting point for it. Also note that a number of the wood parts' dimensions can be traded off; often (but not always) two 24" pieces will work where one 48" piece is specified. I specified what I ended up buying; your suppliers may carry somewhat different sizes.

The list is divided into four sections: wood, glues, other materials, radio.

Wood

Balsa, 1/32" x 4" x 48", 8 sheets

Used when sheeting the wing. Using contest balsa (4 to 6 pound) will obviously make things lighter.

Balsa, 3/32" x 3" x 36", contest weight (4 to 6 pounds), 1 sheet

Used for fuselage sides. You can use 1/8" thick if you like.

Balsa, 1/8" x 3" x 36", contest weight (4 to 6 pounds), 1 sheet

Used for tail(actually only need 2/3 sheet). You can use 3/32" thick if you like.

Balsa, 1/4" x 1/4" x 36" triangle, 2 pieces

Used for joining fuselage components together. 3/16" would be better (lighter and easier to bend), but I've never seen it for sale, so you might have to cut it yourself.

Balsa, 1/8" x 1/8" x 36" stick, 1 piece

Used for wing saddle support (actually only need 1/2 stick).

Plywood, 1/64" x 6" x 12", 1 piece

Used for fuselage side doublers (will only use 2/3 of this).

Plywood, 1/32" x 6" x 12", 1 piece

Used for control horns. You only need about one square inch of this, so you might want to laminate two 1/64" pieces together to get what you need.

Plywood, 1/16" x 6" x 12", 1 piece

Used for washers under wing holddown bolts. You only need about two square inches of this, so you might want to laminate four 1/64" pieces together to get what you need.

Light plywood, 1/8" x 6" x 12", 1 piece

Used for fuselage formers (will only use a piece 1" x 4")

Glues

Thin CA

Used all over the place

Thick CA

Used wherever some time is needed for assembly

Accelerator

Used whenever needed

5 minute epoxy

Used all over the place

Microballoons

Used to make epoxy for tail boom mounting lighter

3M77 spray adhesive

Used to attach sheeting to wing

Other materials

Machine screws, 6-32 x 1", aluminum or nylon, 2 pieces

Used for wing holddowns

Carbon arrow shaft, Beman ICS 500, 32 3/4" long

Used for tail boom. The default boom length is about 19"; if you use a

larger tail you can shorten the boom to 16" and get two booms from one arrow shaft (see Options page).

Ultracote Lite Transparent cover film, one roll

Used to cover tail (will only use about 26" x 8")

Fiberglass cloth, 0.75 oz, 1 yard

Used to cover fuselage (will only use about 10" x 18")

Pink insulating foam, 1 1/2" x 24" x 96"

Cut to make wing cores (will only use about 1/4 of this). Owens Corning InsulPink, sold in Home Depot (and elsewhere), works well.

Transparent tape

Used to hinge tail surfaces.

Sullivan #507 0.030 Push Cable kit, 2 pieces

Pushrods for tail. Includes 2 clevises and 2 threaded couplers.

Radio

Receiver, one

Use any micro-size receiver (e.g. Hitec 555). Remove the case to save some weight.

Sub-micro servos, two

Cirrus CS-20 servos are only 0.43" wide so you can fit them next to each other in the fuselage. Other servos will work; check their size and weight, and consider making a wider fuselage to fit them.

Receiver battery, one

110mAh and 150mAh packs work (trading weight for flight time).

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Options

Here are some optional things that you can do to modify the Terminator design. Please remember - you can modify anything! These pages are here for some ideas, typically for more advanced builders or folks who really want to experiment.

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Cores and More...

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Well, we reeeeaaaally hope you will take advantage of the information here to learn to cut your own cores and learn to do vacuum bagging (or barter with a buddy with a wing core cutter so you don't have to build one yourself) . At the same time, it's clear that this is not for everyone. The demand for pre-cut cores has been pretty strong, and several folks in the community have volunteered to offer these, in case you don't want to do your own. So here we go...

Custom Cores, http://www.custom-cores.com, (email at customcores@hotmail.com) - will provide stock or other cores.

Garrison Aerodrome, http://www.rc-aero.com provides both Terminator cores and a couple of different "short kit" configurations - cores with arrowshaft for boom etc.

This page was last updated on 06/26/00

*** Updates ***

[Courtesy of Bill Grenoble (iflyicrash@aol.com), Denny Maize (rcsoarnut@aol.com) and Joel Foner (joel.foner@fonerassoc.com), this page last updated on June 25, 2000]

June 25, 2000
- CORES and MORE: Added new page, with info on a couple of folks who will cut Terminator cores and provide "short kit" components

August 11, 1999:
- WING: Fixed link problem with leading edge templates (thanks to Bruce Kimball for finding this one).

August 2, 1999:
- INTRO PAGE: Added a section titled "Is the Terminator right for me?"

July 31, 1999:
Thanks to Dan Griscom for these clarifications and additions.
- WING: Added leading edge templates
- WING: Added instructions for using 3M77 spray contact cement for balsa sheeted wings
- FUSELAGE/TAIL: Added a new dimensioned drawing for the fuselage pod.
- FUSELAGE/TAIL: Added clearer directions for adding triangle stock and assembly jig construction.
- FUSELAGE/TAIL: Added an alternate boom alignment method
- FUSELAGE/TAIL: Added detail to notes on installation of wing hold-downs
- FUSELAGE/TAIL: Replaced tail diagrams with smaller (faster download) images, altered instructions to show v-tail mounted under tailboom for alignment simplicity.
- OPTIONS: Added "Tinting Water-Based Polyurethane", a note on how to get tinted finishes with polyurethane with practically no weight gain
- PARTS LIST: Added a parts list!

February 22, 1999:
- GETTING STARTED: Updated wing area - it turns out to be 387 sq inches per description, not an even 400 sq in. (oops!)

- FUSELAGE/TAIL: Removed the reference to the Avia home page, since they have been quite difficult to get a hold of either by phone or email.
- WING: Noted that the location of the front wing bolt is about 3/4" from the LE with the rear bolt about 5" aft of the front bolt.
- WING: Clarified construction sequence, and moved gluing the wing sections together to after the section on finishing the wing
- OPTIONS: Added an options page, and added "Bill's Terminator Tips" and "How to Bag a 4 oz Wing" to it. This page will be the place for advanced techniques and "hop-ups" to the basic Terminator design. Don't feel like you have to try these on your first one - they're probably best left for a bit later when you feel more comfortable with the basic techniques.

January 29, 1999:
- FUSELAGE/TAIL: Updated the Avia Sports web page address (they've moved again!)

January 10, 1999:
- WING: Added a note that you need to have the CompuFoil 98 Airfoil Library to print templates from the loft files on the web site (.lft files). The Terminator uses an airfoil that is shipped with the CompuFoil Airfoil Library, but is not in the core CompuFoil product.

December 21, 1998:
- GETTING STARTED: Added a section with information on two video tapes that demonstrate cutting foam cores and doing vacuum bagging.
- FUSELAGE/TAIL: Added information about two models of Avia kite spars that are useful for tail booms, with a link to the Avia home page that has technical and ordering information (you can get these in limited quantities if your local archery shops are unwilling to sell small numbers of arrowshafts).
- WING: Added a section titled "What Kind of Foam Should I Use?"

November 15, 1998:
- MISC: Separated construction notes into separate pages for faster downloading and easier navigation
- WING: Emphasized the need to check the dimensions of printed PDF airfoil templates to ensure that your printer is rendering these templates at accurate sizes.
- FUSELAGE/TAIL: Added a note about using food coloring as a tint for the urethane on the fuselage, as an optional way to add some color without adding a bunch of weight (paint is a no-no!)

November 14, 1998:
- FUSELAGE/TAIL: Clarified tail boom length - should be 26.5"-27" from wing leading edge to end of tail boom, with ruddervator hinge line aligned to end of tail boom.
- WING: Added a link to "Bill's Terminator Bagged Tips" to the VACUUM BAGGED FIBERGLASS OPTION section - Bill lets his special tip design out of the bag!

November 11, 1998:
- FUSELAGE/TAIL: Added a picture of several fuselage pod designs we've tried in the fuselage construction section.
- FUSELAGE/TAIL: Added a discussion in the v-tail construction section regarding incidence of the tails, and added a note to try both leading edge (LE) and trailing edge (TE) shims while

figuring out the proper incidence.

November 5, 1998:
- FUSELAGE/TAIL: Added PDF diagram of a conventional tail design for the Terminator.

November 4, 1998:
- FUSELAGE/TAIL: Replaced v-tail construction diagram with a new one that has no border to reduce the size a bit and allow easier printing on printers that do not allow narrow margins.
- FUSELAGE/TAIL: Added note about tail boom length in the fuselage section.
- WING: Added a PKZip archive with all of the CompuFoil LFT files for easier downloading

October 30, 1998:
- WING: Added tip dihedral amount to specifications and wing construction sections (oops!) - should be 4" under each wingtip, with a flat center section.
- WING: Added "Assembling the Wing", which describes how to join the wing sections together.
- WING: Added "Wing Hold-Downs", which describes the wing bolts and wood washers added to the wing.
- MISC: Added a link to the Adobe Acrobat Reader Download Site at the top of the document.
- FUSELAGE/TAIL: Clarified fuselage fiberglassing - attachment is done with the water-based urethane.

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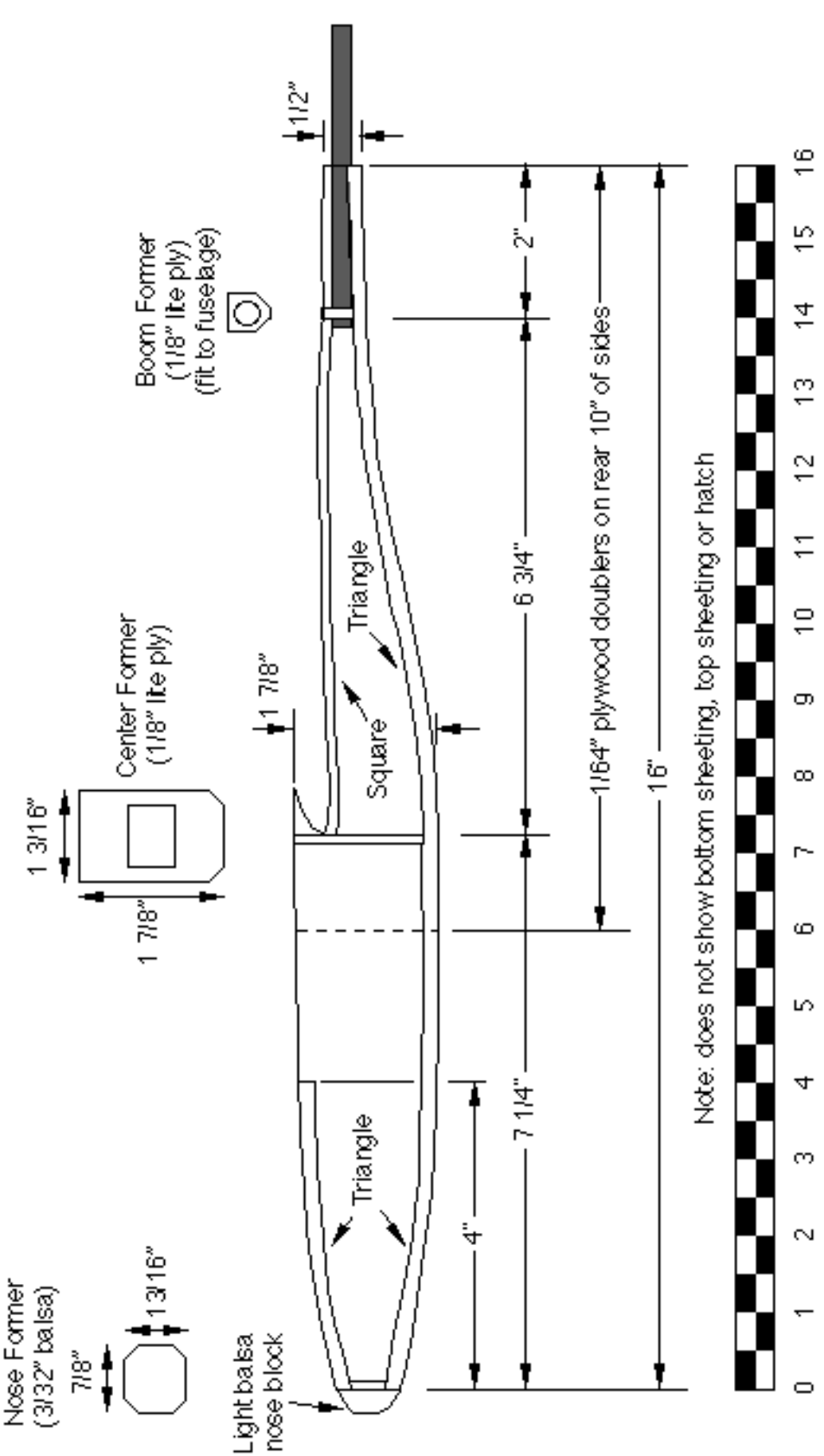
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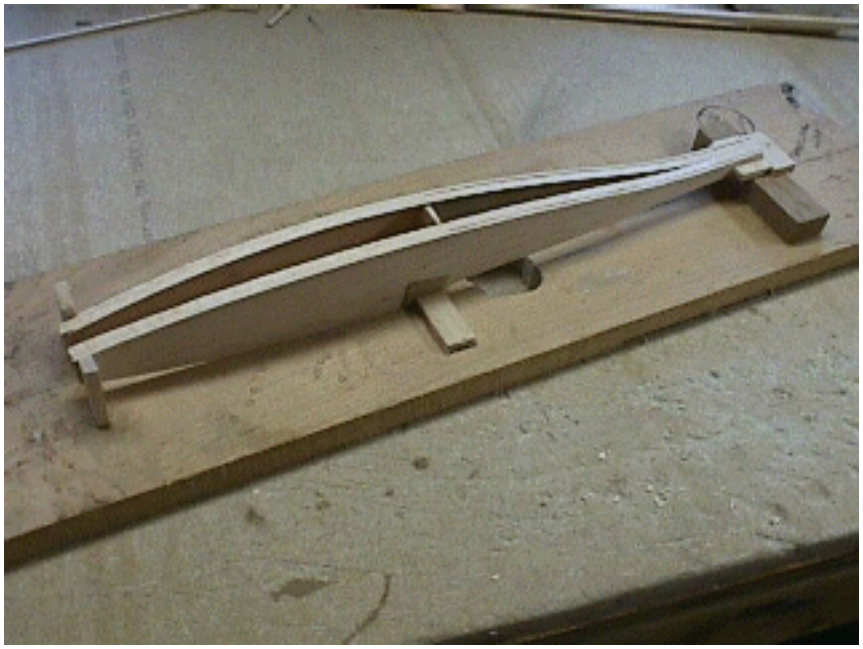
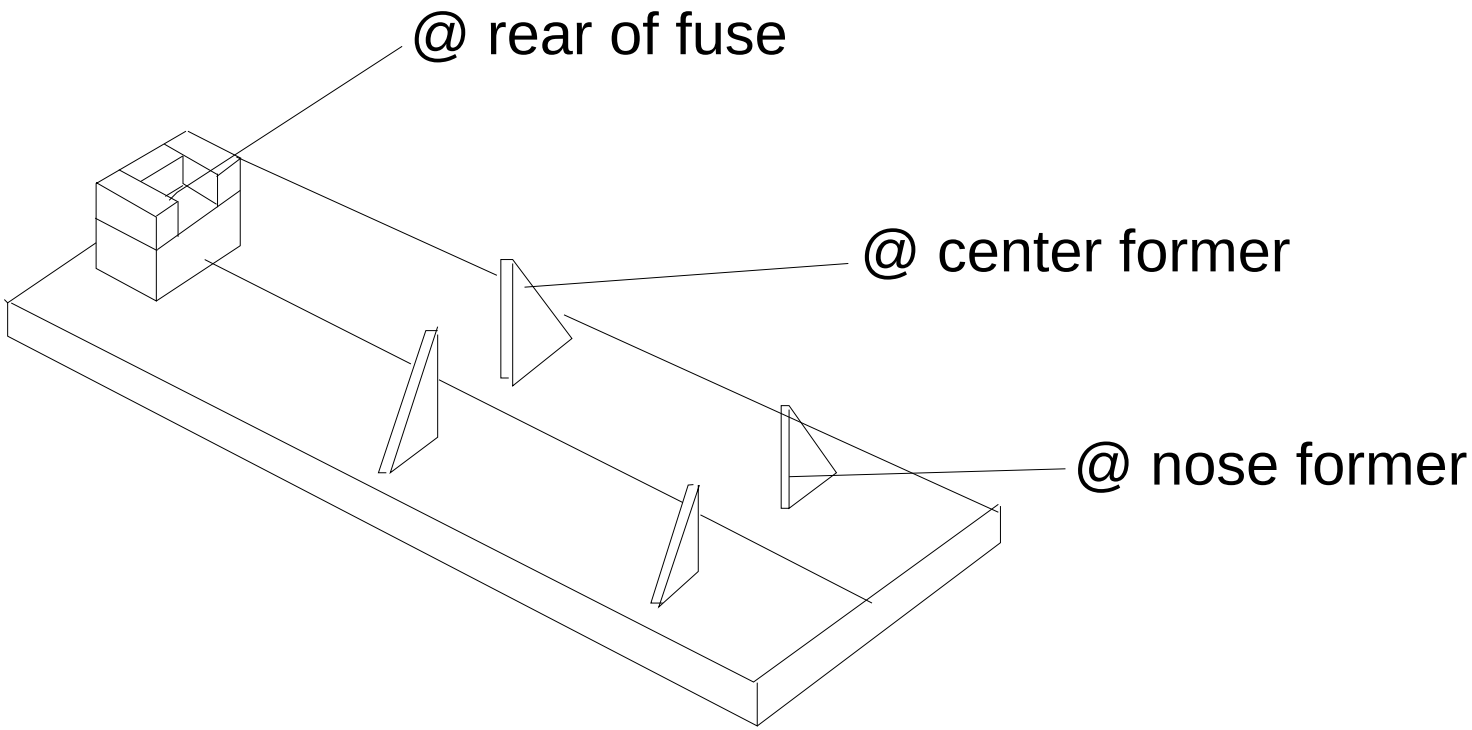
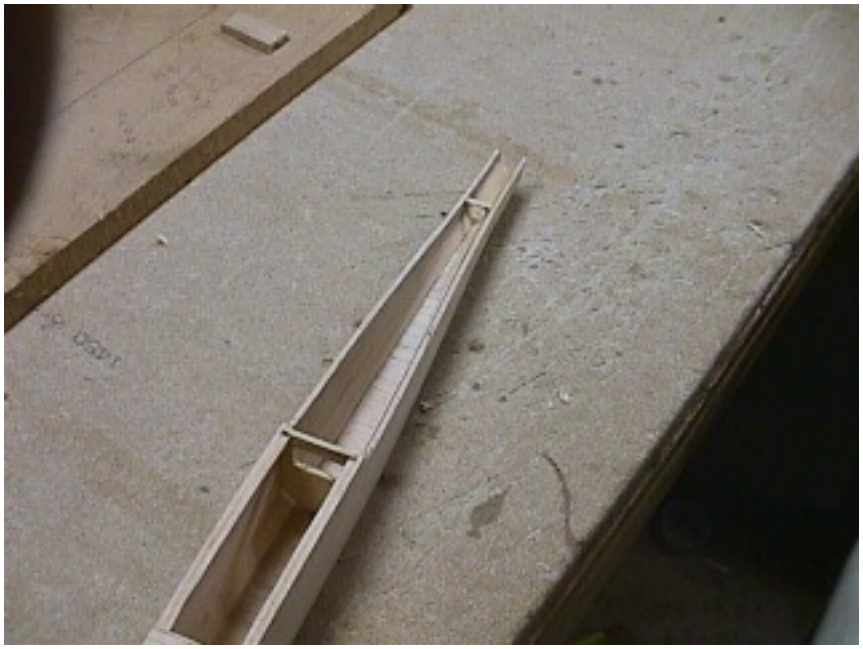
(3/32" balsa)
7/8"
1 3/16"
Light balsa
nose block
Center Former
(1/8" lite ply)
1 3/16"
1 7/8"
Boom Former
(1/8" lite ply)
(fit to fuselage)
1/2"
1 7/8"
Triangle
Square
Triangle
4"
7 1/4"
6 3/4"
2"
1/64" plywood doublers on rear 10" of sides
16"
Note: does not show bottom sheeting, top sheeting or hatch
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

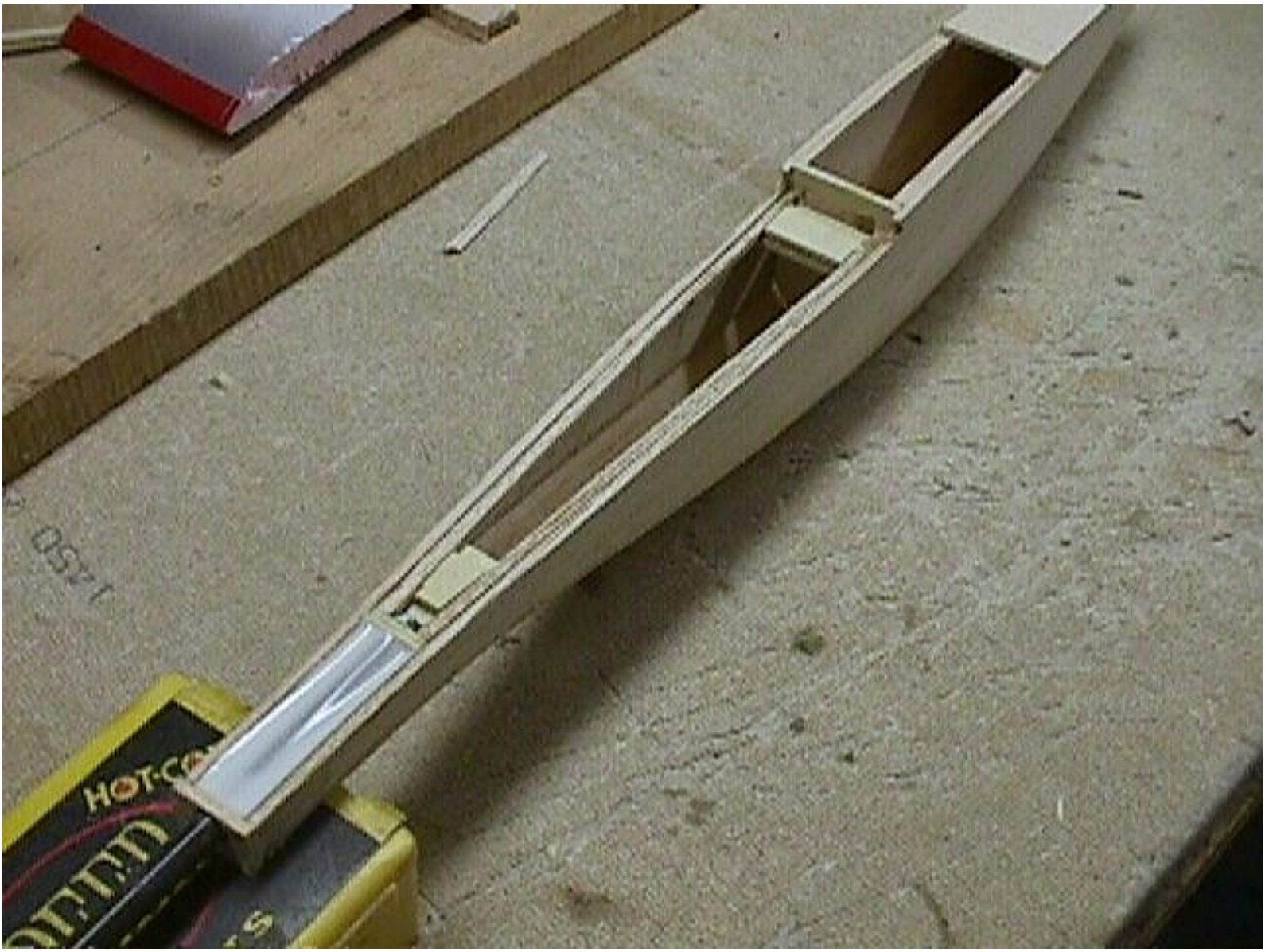


Simle fuselage jig to help insure alignment

Fuselage is built upside down per building instructions







Tinting Water-Based Polyurethane

Comments!

Disclaimer

HOW TO TINT WATER-BASED POLYURETHANE

A nice thing about clear, water-based urethane is that it can be tinted pretty easily. Just add some food coloring (you can get almost any color by mixing the standard colors) to get the tint you want, and then apply it. Presto - tints that can match most any covering with practically no weight! You already knew this, but you should try this on a scap piece of balsa and glass to be sure that your "magic mix" will dry with the color you expected...

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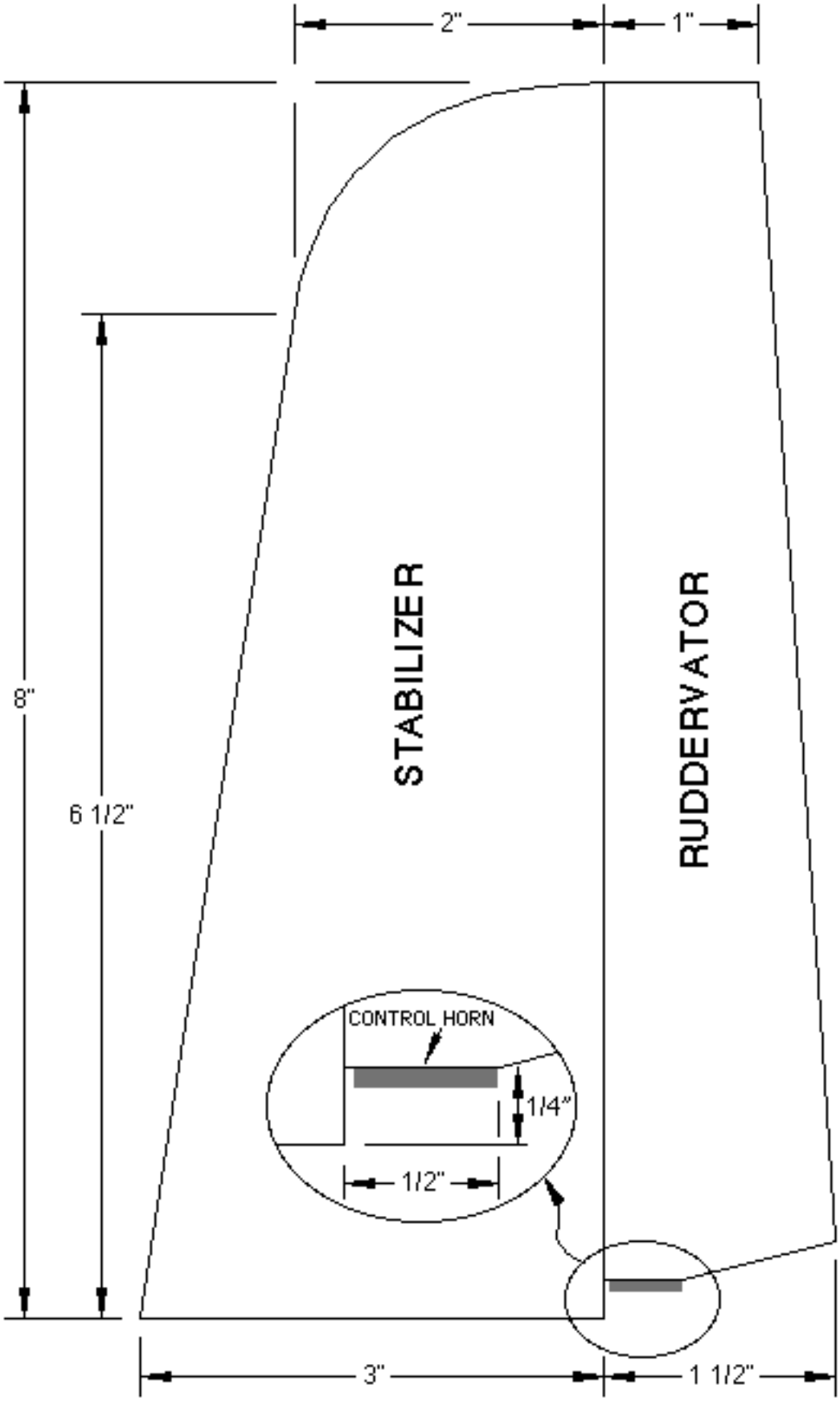
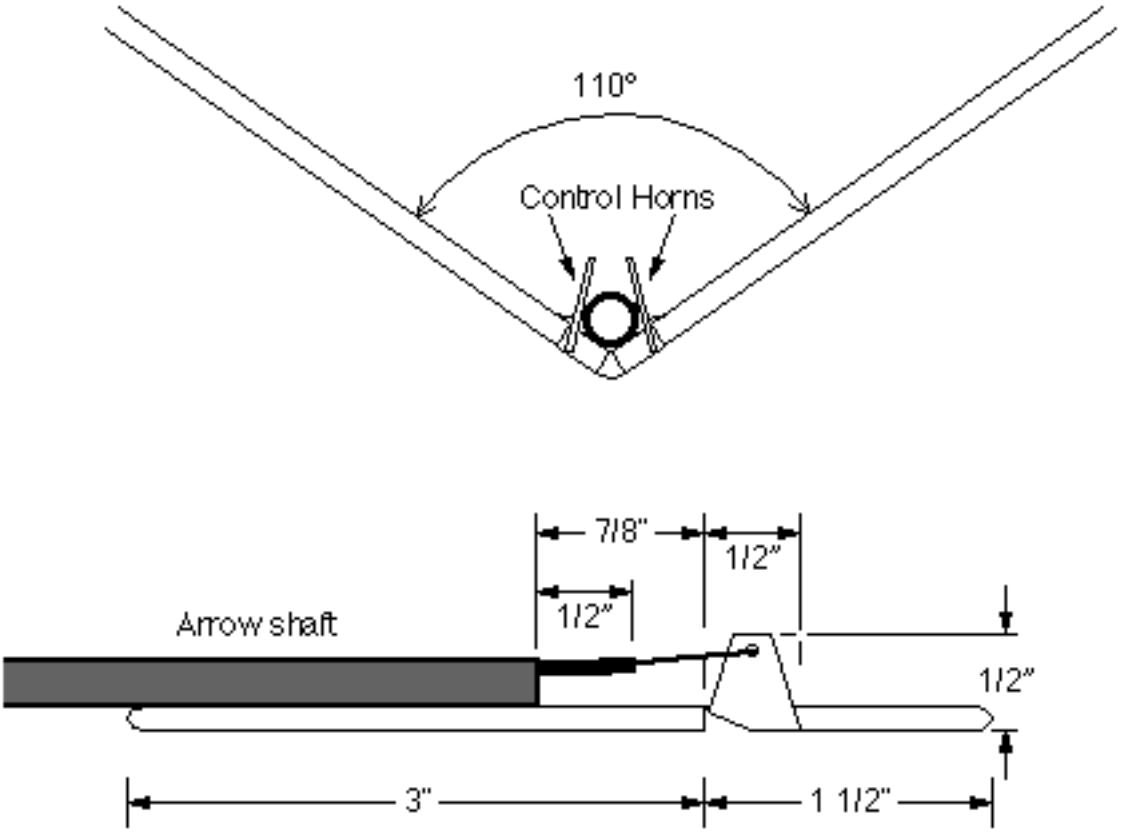
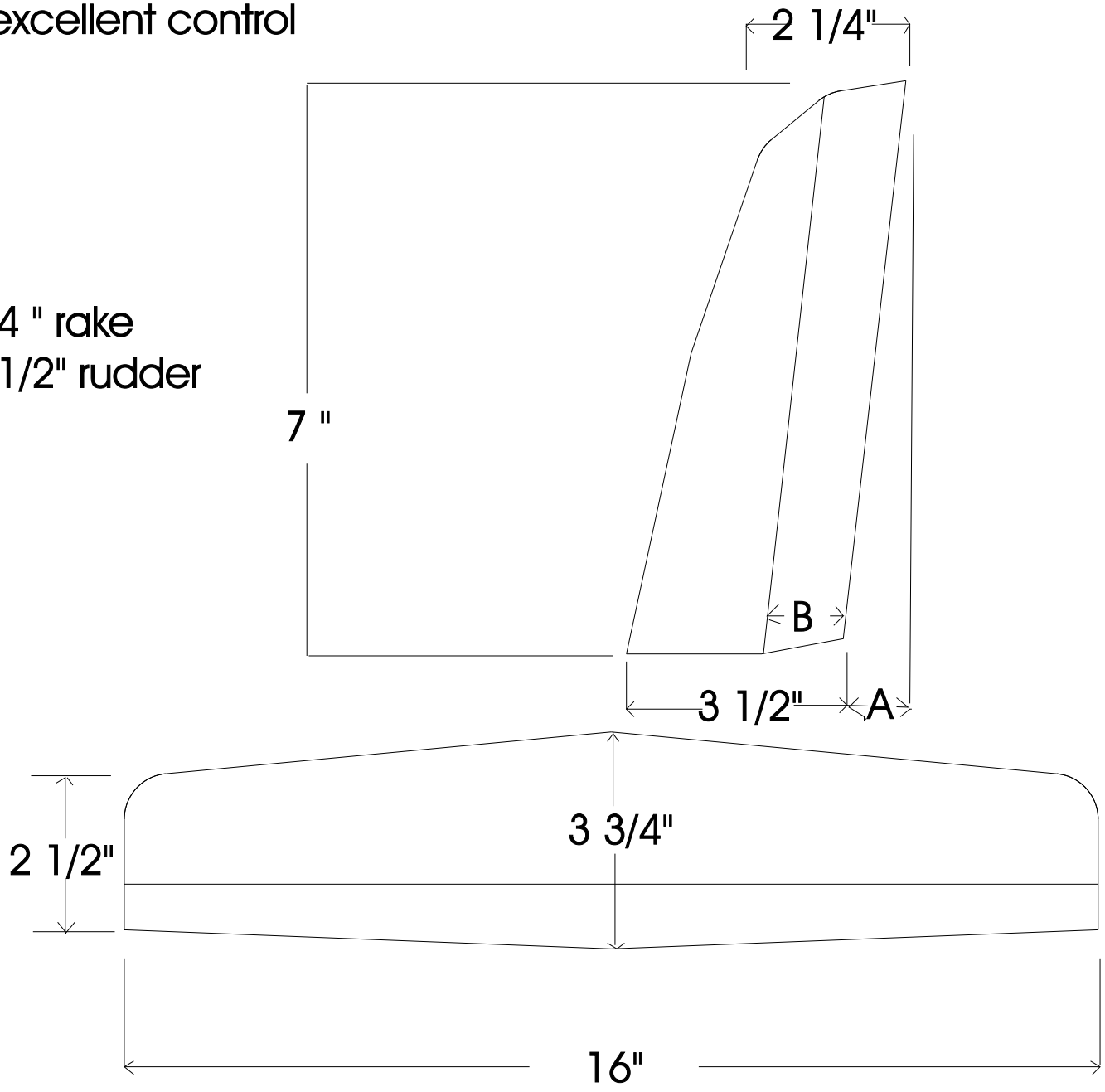
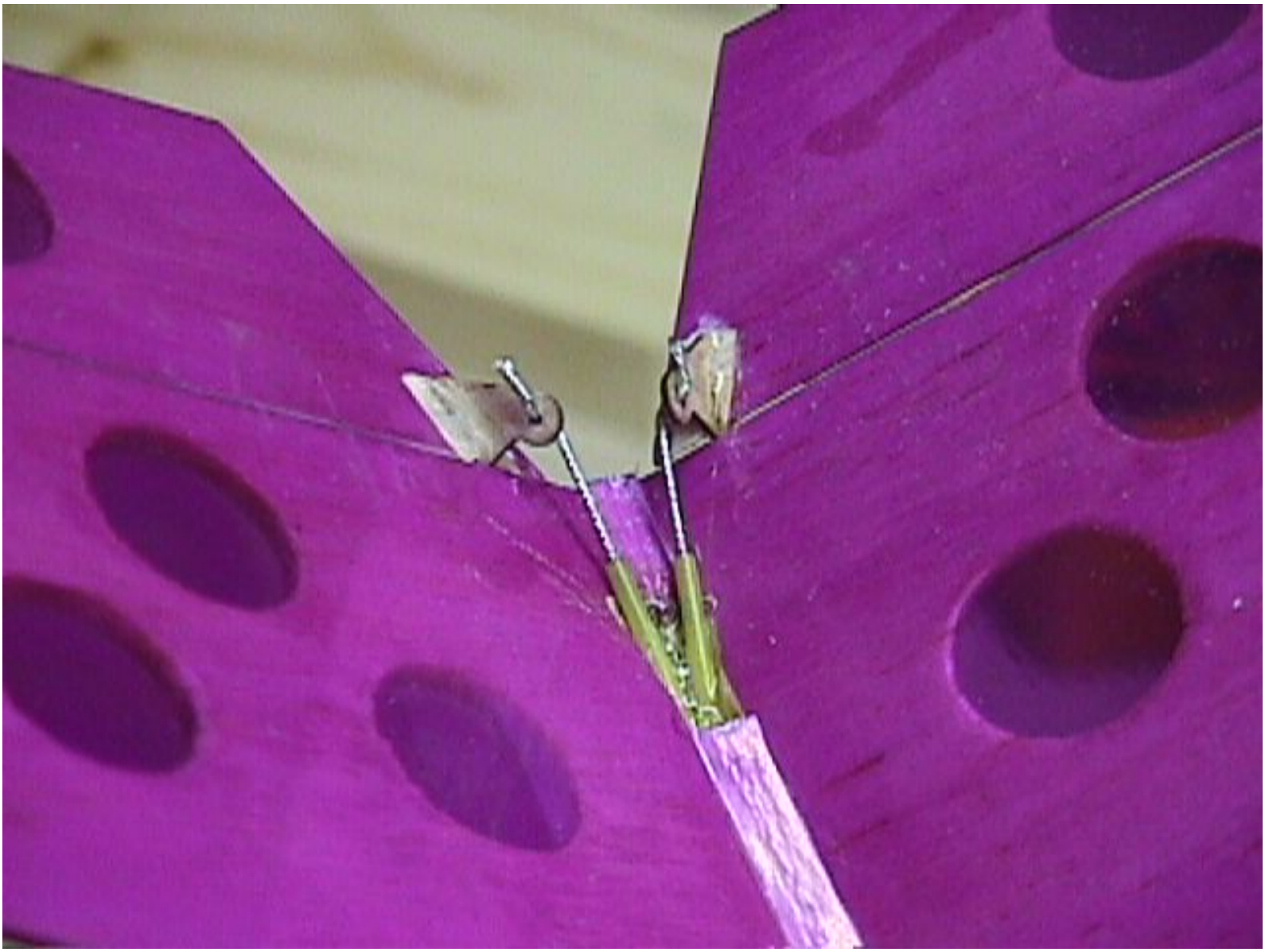

2"
1"
8"
6 1/2"
STABILIZER
RUDDERVATOR
CONTROL HORN
1/4"
1/2"
3"
1 1/2"


110°
Control Horns
7/8"
1/2"
1/2"
Arrow shaft
1/2"
3"
1 1/2"

simple conventional tail
with excellent control

A 3/4 " rake
B 1 1/2" rudder





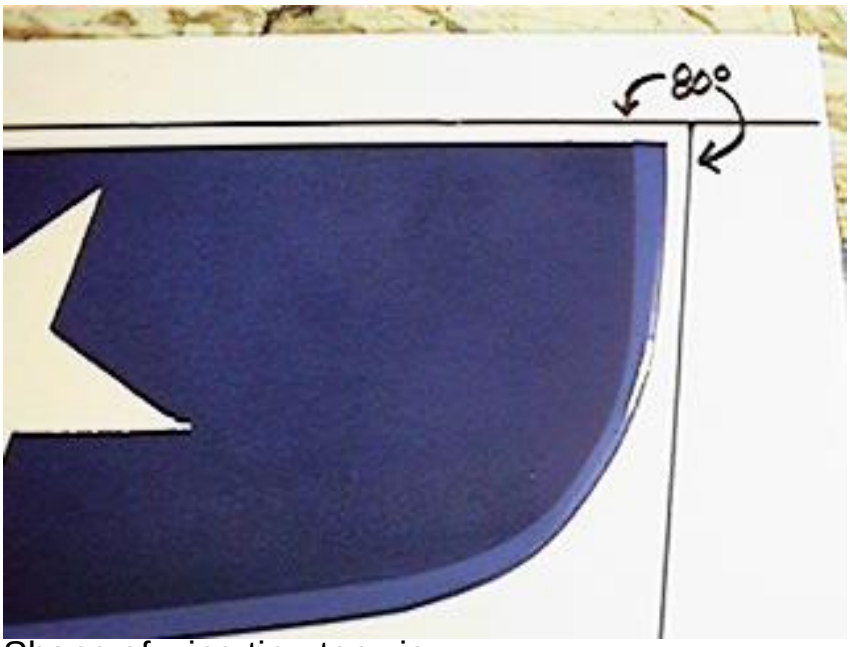
Bill's Terminator Bagged Tips

Comments!

Disclaimer

[Courtesy of Bill Grenoble, November 1998]

On the wing tips, I make a diagonal cut at 80 degrees from the TE leading inward, then use a 6" radius arc to lay out the curves (do it once on a piece of posterboard and cut the curve section out with sissors).



Shape of wing tip - top view

Once you have the mylars cut for the first one, just lay the core in and trace the mylar outline on it to cut the curved tip for the next ones.

Then flip the core over, and sanding CAREFULLY, scallop the underside of the tip down to a uniform 1/8" thickness or so, right from the LE around to where it starts to taper to the TE.

Blend it over the first 2 or 3 inches inboard so that you don't have an abrupt taper at the tip. Your mylars will conform, and you end up with a very nice laminar flow tip. (but what do I know) <BG>

End view of tip after Bill's "tip scalloping" work

We have noticed that shaping the tips before attaching the 2oz leading edge glass cloth strip adds some extra feet to our throw height in reduced drag. At my age, I need all the extra feet I can get. Seems to help tip stalling also. (this ship does not tip stall easily)

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How to Bag a 4 oz Wing

Comments!

Disclaimer

[Courtesy of Bill Grenoble, iflyicrash@aol.com, February 1999]

Various folks have written to us suggesting that we have some "magic secret" that allows us to create four ounce wings (and some that are significantly less than 4 oz). Well, nothing could be farther from the truth, and this page will prove it!

How do we get wings that are light? The tradeoff is easy - less glass, less epoxy, and correspondingly less strength. If you try to build a set of wings using these instructions, please be forewarned that wings this light are more fragile. If you tend to "bonk" things on landing, or have a habit of pulling down hard on launch you may fold these up, but if you are getting to the point where things are under control a plane built using these techniques will float noticeably better.

Enough philosophy - here we go! (the following is from an email by Bill reviewing his techniques - by the way the big "technique" is practice bagging many wings)

"What is your secret?" We have no secret at all. The Web-site shows our layup using 1.4 ounce cloth and doublers, and tells you to drop to .75 ounce cloth with doublers if you want a lighter weight wing. The web lay-ups average about 4.1 to 4.2 oz for light .75 ounce cloth, and 4.3 to 4.5 for the 1.4 oz cloth.

My latest wing lay-up for 60" HL is as follows.

- Center core pink foam (Home Depot) 7.25" chord 21"core weight about .63ounces
- Double taper tip panels 1# virgin white foam 7.25 chord to 6.0 to 3.5" X 20" long
- Both panels together weigh .92 ounces.

I use one layer of .75 ounce cloth on all panels, plus full span 3 oz "tacky thread" carbon spars.

The last 15 wings average 3.5 oz Poly, and 3.8 oz Poly- flaperon. (because I use an extra .75 oz doubler on the root end 10" wide over servo cut-outs, and a doubler on top where I will leave the skin hinge for the ailerons.)

The airfoil I have used on these is the 6063 thinned to 6% and cambered to 1.8%

NO SECRETS

If you weigh your epoxy, (as you should every wing to get consistant) you will find that these wings can be bagged with about 1.6 to 1.7 ounces of epoxy for the whole wing. With a total dry weight of 1.8oz poly, & 2.1oz PF you add on the weight of the epoxy (calculations below) of 1.7 oz per wing to get a finished weight of 3.5 to 3.8 ounces.

One of our new first time baggers here just did his first HL wing at 3.3 ounces. He is Tom Miller tmiller363@aol.com Tom came over a few times to learn layup in preparation for his first wing.

How do you measure and weigh your epoxy? ***Epoxy is the first and only place you look for weight. PERIOD!!***

West 1 gal pumps put out 1.25 ounces total for both pumps EZ Lam puts out 1.5 ounces total for both pumps.

How to Weigh Your Epoxy

1. Weigh your plastic picnic cup first
2. Pump out both resin and hardener into it
3. Then weigh it all, and deduct the cup weight.
4. Now weigh your 3" foam roller (you made three 3" from one 9" roller to save money like us , didn't you?)

One pump of resin & hardener from West pumps will easily do your first panel with cloth wetted out.

Wet out your 2oz LE doublers, (start wetting out the cloth by dribbling epoxy dribbles back and forth longways on the top,and bottom right through the .75 ounce cloth), and lay down your carbon tacky thread spars, add your doublers if it is a PF, and start the wet out for the second panel (or third if a three panel wing).

This gets tricky and will only be learned by doing. The roller is already wetted out and you won't be using near as much epoxy as the first panel. *If you mix up a full pump of each, you will be working with the potential to make you second wing panel 1.25 ounces plus what you spread onto the second panel from the first batch.*

This means your first panel is laying in the bag at a weight of about 1.75 ounces finished, and you dumped about .2 or so ounces already onto the second panel which already gives it a weight of 1.1 dry, + .2 or total 1.3ounces.

If you use all the epoxy from the second pumping, or 1.25 oz, plus the weight

already of 1.3, your second wing half will weigh about 2.55 oz. *This results in an un-matched set weighing 4.3*.

With a little preparation and calculating, you will have a set of 3.5 ounce wings that match. I see mis-matched wings all the time, there is no secret as you put it, and all the work up sheets in the world can't help you if you don't learn the basics to light wings. It took us over 170 wings in a year to learn what we can do in predicting the weight of wings.

Weigh the components, balance them out, learn what epoxy weight to use with each weight or combination of cloth weights and doublers. Dig in and do it, produce your own data.

Once you understand where the weight comes from in bagging, you can start to experiment. My personal wings are bagged for performance/weight/airfoil design. Durability is second. If you build to fly well, you will not survive too many hard crashes.

If you crash alot, and don't break wings/things, you have built too heavy. Build to Fly.

More later, let me know how you make out, it's not easy bagging light AND strong.

Bill Grenoble

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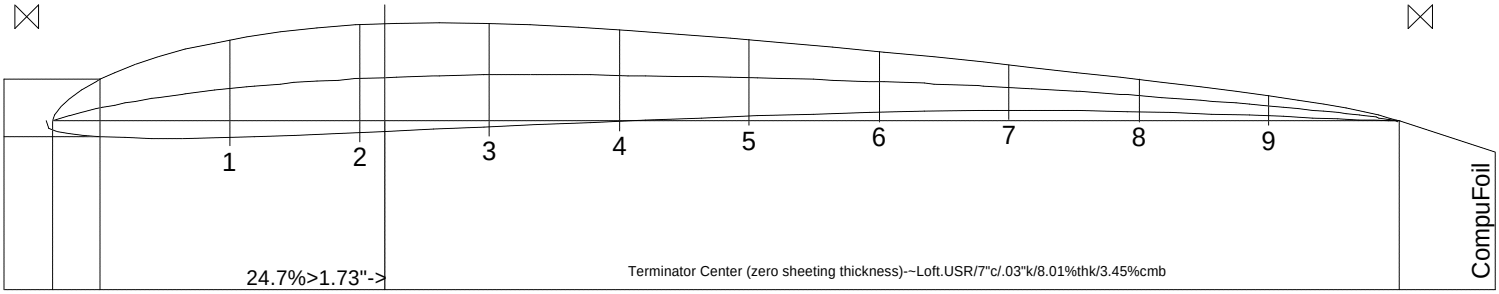
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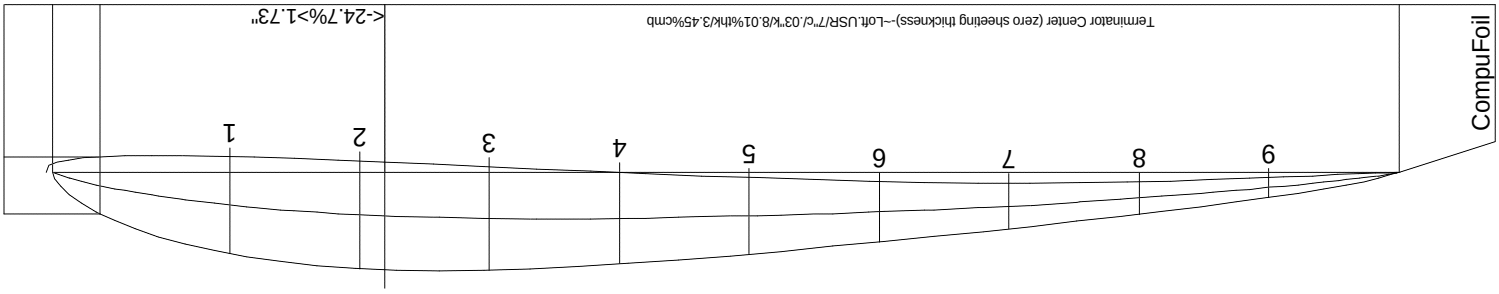
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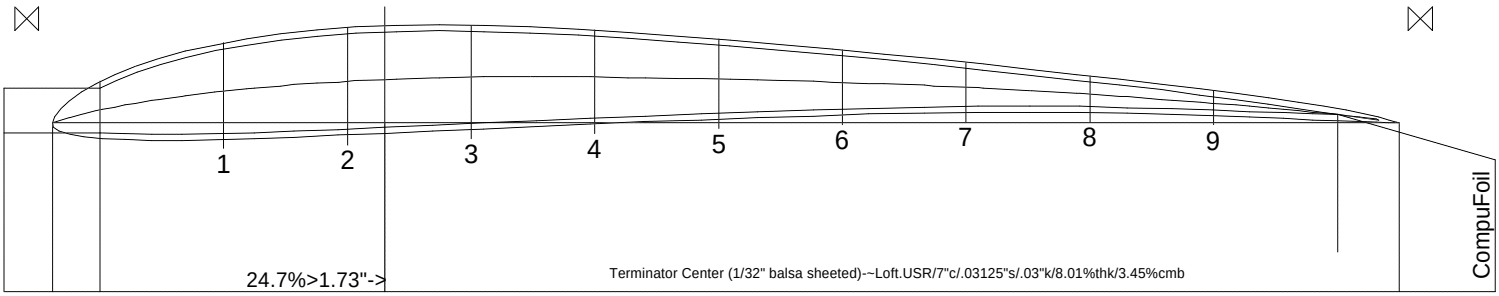
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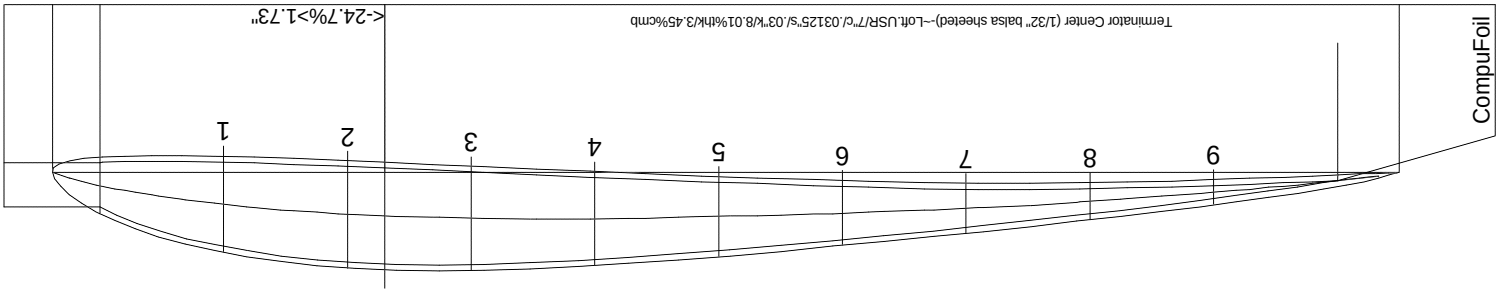
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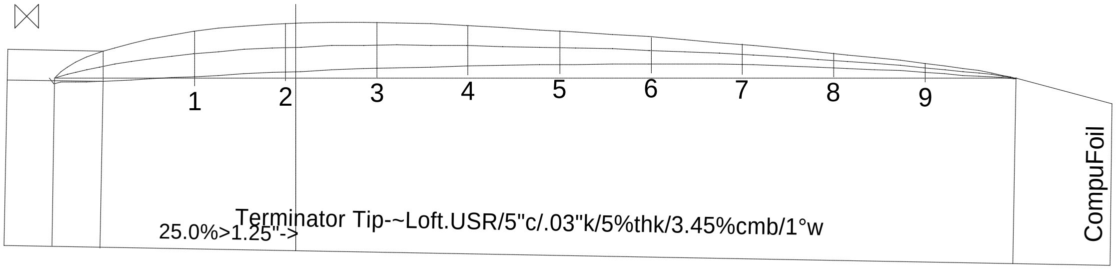
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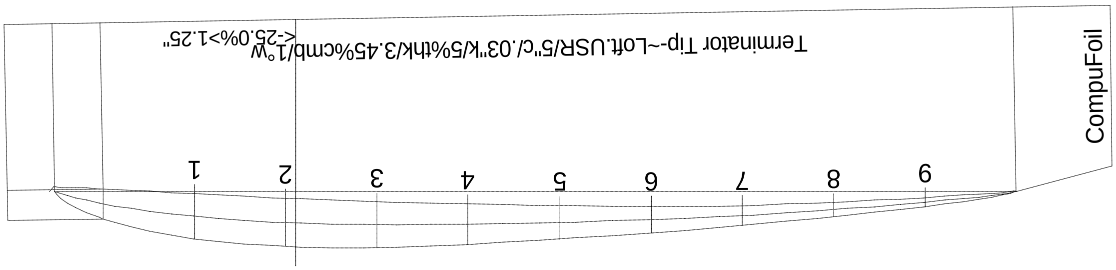
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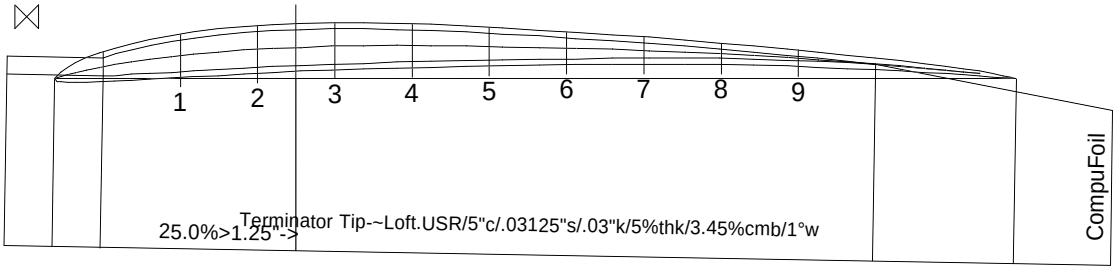
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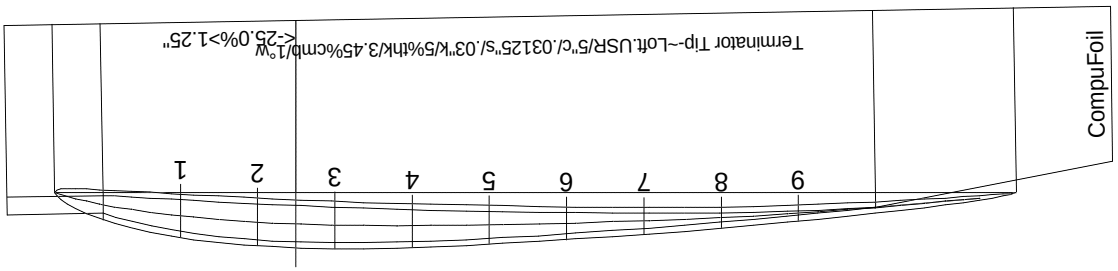
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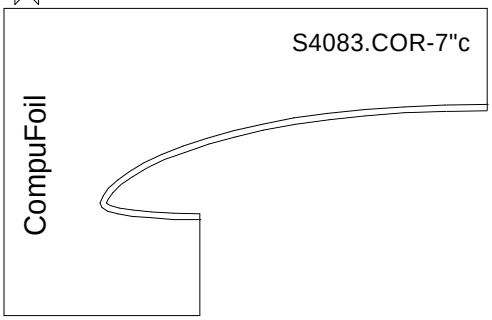
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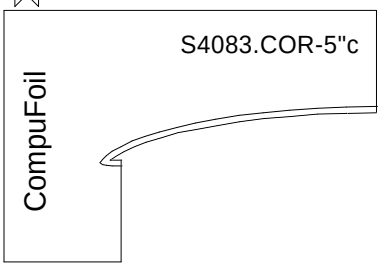
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